

Testimony of Dr. Knute Nadelhoffer, PhD  
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"Climate Science and EPA's Greenhouse Gas Regulations"

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Chairman Whitfield, Ranking Member Rush, and members of the Committee, thank you for inviting me to testify on this very important matter. My name is Prof. Knute Nadelhoffer and I am the Director of the University of Michigan Biological Station in Pellston Michigan, a field station near the geographic center of the Great Lakes Basin which hosts researchers from around the world who study ecosystems and their constituent organisms across the upper Great Lakes region. I am also a Professor in the Department of Ecology and Environment at the University of Michigan in Ann Arbor with 30 years of research experience. I will address the current and expected ecological impacts of climate change, with a particular emphasis on the Great Lakes basin - a region that holds approximately 20% of the world's surface fresh water, and is a large industrial-agricultural region highly dependent upon services and products provided by natural systems.

My expertise is in arctic tundra and north temperate forest ecology and biogeochemistry. I have worked in North American and European forests since my graduate studies in the late 1970s and have conducted research in the Arctic (mostly on Alaska's North Slope) since the mid-1980s. Overall, I have over 30 years of research experience studying ecology and nutrient cycling in the field in forest and tundra environments.

I now direct the University of Michigan Biological Station— a century-old field station located near the center of the Great Lakes basin, south of the Mackinac Straits, with access to the watersheds and shorelines of Lakes Michigan, Huron and Superior. Teams of researchers (biologists, chemists, atmospheric scientists, and others) from around the world work at the Michigan Biological Station to understand the functioning of land, air, and water systems, and how they interact with humans. Measurements and research results from over a century of work at my field station and others across the Great Lakes region are providing a comprehensive picture of changes in climate and associated changes in natural systems during this period. As a result of my colleagues and my own research, in both the Great Lakes Basin and the Arctic, I am very aware of climate change impacts on environments and ecosystems in northern regions.

## INTRODUCTION

We know the climate is changing. It is real, it is happening, and the impacts are becoming clearer the more we observe and study plant and animal distributions, nutrient cycles, atmospheric chemistry, and long-term, large-scale weather and climate patterns. The United States has become both warmer and wetter over the past century. In the Great Lakes region, total annual precipitation (rain plus snow) has been relatively constant during the past 50 or so years. However, the seasonality and intensity of precipitation events has changed dramatically over this period. More of our rain now falls as storms in late winter and spring, leading to early season floods that often exceed the capacities of storm-water handling systems of our coastal towns and cities, and which delay farmer access to fields. Overall, heavy downpours and major floods are becoming more common. Heat waves have increased in both frequency and duration. Spring is arriving earlier and winter, later. Winter ice cover in all five Great Lakes, although highly variable from year to year, has decreased dramatically in past decades. This is consistent with steady decreases in summer ice cover extent and thickness recorded by satellite observations of the Arctic Ocean. These changes adversely impact people, wildlife, natural ecosystems and agricultural productivity.

These basic facts are well documented both within the scientific literature, and elsewhere. More importantly, the science has become essentially irrefutable on this point -- rising concentrations of greenhouse gases (mainly carbon dioxide, methane, and nitrous oxide) in the atmosphere, resulting from fossil fuel combustion and other human activities, are the primary drivers of these recent changes in the climate system. There are no other viable, science-based explanations for the effects we are seeing.

Our best research shows that we cannot ignore what the science is telling us about these changes any longer. This sentiment is supported by nearly 149 (as of March 5) scientists from Michigan who have signed a letter appended to my testimony. This is just the most recent, and regionally significant, endorsement of the IPCC assessments, the fourth of which, published in 2007, involved over 500 expert lead authors (including 5 from Michigan) and more than 2000 reviewers (myself included). Congress, likewise, should support efforts to limit human-caused climate change, namely fossil fuel emissions, in order to protect our nation's interests and sustain the natural and agricultural systems on which we depend for food, fiber, clean air, and clean water. Stabilizing the climate, by limiting and eventually reducing greenhouse gas emissions, will help maintain these

and other "ecosystem services," which together contribute to our quality of life and economy.

## **The Great Lakes Region**

Within the eight states of the Midwest region – Illinois, Wisconsin, Indiana, Ohio, Iowa, Minnesota, Missouri, and Michigan – lies the largest group of freshwater lakes in the country and the world. These lakes provide clean, fresh drinking water to tens of millions of people. Long accustomed to utilizing this unique natural resource for shipping and manufacturing purposes, the Midwest produces 40% of the US industrial output and provides 30% of the US foreign agricultural exports. A recent analysis by the Michigan Sea Grant showed that more than 1.5 million jobs, which generate \$62 billion in wages, are directly connected to the Great Lakes. The largest sectors include manufacturing (almost 950 thousand jobs), tourism and recreation (over 215 thousand jobs), shipping (118 thousand jobs), and agriculture/fishing/food production (118 thousand jobs).

Much of my research has focused on the region around Lake Michigan, encompassing the states of Illinois, Indiana, Michigan and Wisconsin. This region is experiencing profound ecological changes due to climate change including changes in precipitation and temperature that alter plant growing conditions, wildlife habitats and entire ecosystems. Observed climate change effects in the region include increases in temperatures – 4°F (2.2°C) in the North and 1°F (.6°C) in the South (Easterling & Karl

2001). Growing seasons have advanced by nearly a week over the past 50 years. Lake Superior is warming at an alarming rate; Average water temperature increased by 4.5 °F from 1979 to 2006, or approximately 0.2 °F per year during this 28-year interval (Austin & Coleman, 2007). This largest body of fresh water in North America is feeling the impacts of a warming climate, and is serving as key indicator of changes that are already occurring across the region. Given the huge volume of water in this lake, the energy required to raise temperatures this quickly is stunning. Similar trends are observable in smaller lakes, where we measure decreasing lengths of winter ice cover, more evaporation from lakes, longer periods of “stratification”, and warmer summer water temperatures. Warmer water temperatures, together with more intense spring rains and flooding which deliver more sediments and nutrient loadings to our lakes, lead to more oxygen depletion in deep waters, fish kills, nutrient enrichment, and greater variation in water levels. Warmer waters also tend to favor invasive species adapted to warmer conditions. As a result, highly valued, cold-water species such as trout and small mouth bass are at risk of being replaced in many of our waters over the short-term, and most certainly as we progress through the 21<sup>st</sup> century.

Additionally, higher winter temperatures have allowed destructive invasive terrestrial species like the kudzu plant and plant pests such as the gypsy moth and Hemlock wooly adelgid to spread northward and eastward.

Summers and winters have been wetter than average for the last three decades, the wettest period in more than 100 years. The Midwest has experienced two record-breaking floods in the past 15 years and heavy downpours are now twice as frequent as they were a century ago.

These changes are not meaningless or benign. They will likely accelerate into the future if we continue on our current emissions path. Of particular concern are heavier and more frequent winter and spring precipitation events that lead to increased spring flooding. Hotter and drier summers stress plants, animals and livestock, decrease production of key crops, and lead to severe heat waves and poor air quality in cities. Early season flooding and hotter, drier summers are also increasing insect and waterborne diseases. Future effects of climatic warming and changes in seasonality of precipitation on water levels in the Great Lakes are not well understood. However, there is potential to impact recreation, shipping, and potable water, all of which are key economic drivers in the upper Midwest.

About \$3.4 billion and 60,000 jobs rely on the movement of goods within the Great Lakes-St. Lawrence shipping route annually (Easterling & Karl 2001). Lower water levels along the system could jeopardize this relatively inexpensive and effective method of transporting manufactured goods. If water levels drop significantly, dredging may be the only alternative to salvage this system. It is estimated that between 7.5 and 12.5 million cubic yards would need to be dredged annually at a cost of \$85-142 million (Great Lakes Regional Assessment Group 2000). System connectivity is predicted to become 25% impaired, causing a loss of \$850 million annually (Easterling & Karl 2001). Increased incidences of drought will likely place an additional stress on the water conveyance system. For example, a 1988 Midwest drought cost the region over \$49 billion, in part because river commercial shipping had to be replaced by more expensive railroad transport due to the Mississippi River's reduced water levels (Easterling & Karl 2001).

The Great Lakes region also stands in the middle of important transitions between prairie and woodlands, and central and northern forests. Forestry is an integral part of the economic structure in the Midwest. Over 90% of public and private forestland is used for commercial forestry, resulting in economic activity valued at \$41.6 billion (Great Lakes Regional Assessment

Group 2000). The sector employs 200,000 people and produces \$27 billion in forest products.

Depending on the pace of climate change, we stand to see substantial changes and shifts in the habitats and abundance of trees, plants, animals and insects around Lake Michigan. Mammals and other species are increasing their ranges northward, and forests and other systems are becoming more vulnerable to invasive diseases and defoliating insects. Many of the economically valuable timber species – aspen, jack pine, red pine, and white pine – may be lost due to warming of the climate (Easterling & Karl 2001; Hellman, Nadelhoffer & others, 2010). The pine-aspen pulping/wood fiber industry may be eliminated entirely as the forested landscape shifts toward oak and hickory species.

In addition there will likely be a decrease in “good” or desirable species (e.g. bats that eat insects considered a pest by farmers) and an increase in “bad” species (eg aggressive invasive species such as kudzu). As plant species shift and change, or disappear, so to do the insect and animal species that depend on them.

Agriculture is particularly susceptible to the negative impacts of current and projected climate change trends in the region, including substantial crop losses due to weeds and pests, as well as changing precipitation and temperature patterns. This means that farmers will lose money and prices for food paid by consumers will rise at a time when costs are rising dramatically. A big concern in the region is drought-like conditions resulting from elevated temperatures, which increase levels of evaporation, contributing to decreases in soil moisture and reductions in lake and river levels. Although longer growing seasons provide potential for increased crop yields, increases in heat waves, floods, droughts, insects, and weeds will present increasing challenges to managing crops, livestock, and forests.

Potentially negative impacts are expected to the \$5.7 billion dairy industry, since milk production by dairy cows is temperature sensitive and declines when temperatures advance beyond a certain threshold (Great Lakes Regional Assessment Group 2000). Research also indicates that soybean yields could decline in Illinois as much 55% by the end of this century given the current pace of temperature increases. Weed induced losses for corn could increase 22% in the Great Lakes states, and for soybeans

losses could be 35%. This is not a minor concern, given the tremendous economic importance of agriculture to the Lake Michigan states.

The region is well-known to outdoor recreation enthusiasts. Already, ski resorts and businesses profiting from winter activities such as snowmobiling and ice-fishing are feeling impacts of shorter winters and more frequent winter thaws. Portions of the industry are likely to suffer because of climate change. For example, the distribution of prominent game and other bird species (e.g. waterfowl, warblers, perching bird species) may be altered, affecting hunting and bird-watching. In Michigan, Minnesota and Wisconsin alone, \$4.7 billion was spent in 1996 on hunting, and bird-watching generates \$668 million in retail sales and supports 18,000 jobs.

## **CONCLUSION**

Climate change is impacting the Great Lakes region now, more so than in many other areas of the country. Future changes will be greater than those we have experienced thus far, unless we act to stabilize and reduce GHG emissions. We cannot hide from these changes. As a scientist I cannot ignore what solid and rigorous research is telling me every day. If we care about the future economy and environment of the Great Lakes – this amazing natural resource that is unique in the US and the world, that supports the livelihoods of millions of people and generates billions in economic activity, we must start now to stabilize atmospheric greenhouse gas emissions – not only carbon dioxide, but also methane, nitrous oxide, and ozone. We cannot just hope to adapt to the dramatic changes that are upon us and that will increase in coming decades if we do not act to mitigate and reduce emissions.

In light of all of the scientific facts relating to climate change, Michigan scientists have overwhelmingly voiced their support for strong federal policies to reduce fossil fuel emissions. Science is not a partisan endeavor. It provides us with the best information available about how the earth and regions such as the Great Lakes basin are responding to the inexorable and unprecedented (in human time-scale) increases in atmospheric

greenhouse gases. We ask that Congress support sound legislative and regulatory policies to limit harmful greenhouse gas emissions that threaten our health, welfare, environment and our economy.

Thank you.